

The extragalactic nature of the serendipitous *BeppoSAX* source 2MASX J14585116–1652223^{*}

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Abstract

As a follow-up of the X-ray serendipitous detection of the source 2MASX J14585116–1652223, medium-resolution optical spectroscopic observations collected at the 1.5-metre “Cassini” telescope of the Astronomical Observatory of Bologna were performed. This allowed us to determine the extragalactic nature of this X-ray source, which is a Type 2 Seyfert galaxy at redshift $z = 0.068 \pm 0.001$. This result points to the fact that 2MASX J14585116–1652223 hosts one of the very few Active Galactic Nuclei detected so far in the hard X-ray band above 20 keV, in particular at $z > 0.05$. Other optical and X-ray properties of this object are also discussed.

Key words: X-rays: galaxies — Techniques: spectroscopic — X-rays: individuals:
2MASX J14585116–1652223 — Galaxies: Seyfert
PACS: 95.75.De, 98.54.Cm, 98.62.Py, 98.80.Es

1 Introduction

The X-ray emitting object 2MASX J14585116–1652223 was serendipitously discovered by *BeppoSAX* and detected in the 1.5–100 keV range during the

^{*} Based on observations collected at the Astronomical Observatory of Bologna in Loiano, Italy.

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observation of the Seyfert 2 NGC 5793. Details on the discovery are reported in Landi et al. (2005). The source, located at coordinates (J2000) $\alpha = 14^{\text{h}} 58^{\text{m}} 50^{\text{s}}.7$, $\delta = -16^{\circ} 51' 50''.7$ is, according to the NASA/IPAC Extragalactic Database¹, a bright irregular spiral galaxy belonging to the Two-Micron All Sky Survey eXtended (2MASX) Source Catalog² (Skrutskie et al. 1997). A DSS-II-Red³ image of the optical field of this source is shown in Fig. 1.

The source was detected both by MECS and PDS instruments onboard *BeppoSAX* and showed a spectral shape described by a flat power law (of photon index $\Gamma \sim 1.2$) with a 2–10 and 20–100 keV flux of $\sim 10^{-12}$ erg cm⁻² s⁻¹ and $\sim 10^{-11}$ erg cm⁻² s⁻¹, respectively. These spectral characteristics imply that 2MASX J14585116–1652223 is an Active Galactic Nucleus (AGN) which is either absorbed at low energies (by an hydrogen column $N_{\text{H}} \sim 4 \times 10^{22}$ cm⁻²) or with an intrinsically flat spectrum. Due to the lack of spectral information below 1.5 keV it was not possible to tell which of the two interpretations above holds true for the source.

Very little is known about this source except for its optical/near-infrared (NIR) magnitudes. The source is fairly bright with a total 2MASX NIR photometry of 14.4, 13.6 and 13.0 magnitudes in the *J*, *H* and *K* bands, respectively, and an extension of 11". The optical counterpart has magnitudes $B \sim 16.4$ and $R \sim 15.1$ according to the USNO-A2.0 catalog⁴. No X-ray detections other than the *BeppoSAX* one are reported in the literature. The source was however observed by *ROSAT* in the 0.1–2.4 keV band, but no detection was achieved; this latter fact is again consistent with the presence of strong absorption. No detection in the radio bands was found in the literature.

In order to confirm and classify more accurately the nature of this source, we performed medium-resolution optical spectroscopic observations on it with the 1.5-metre telescope of the Astronomical Observatory of Bologna. This paper is organized as follows: Sect. 2 describes the observations, Sect. 3 will present the results and a discussion on them, whereas in Sect. 4 the conclusions are drawn.

2 Optical observations

The Bologna Astronomical Observatory 1.52 metre “G.D. Cassini” telescope plus BFOSC was used to spectroscopically observe 2MASX J14585116–1652223.

¹ available at <http://nedwww.ipac.caltech.edu/>

² available at <http://www.ipac.caltech.edu/2mass/>

³ available at <http://archive.eso.org/dss/dss/>

⁴ available at <http://archive.eso.org/skycat/servers/usnoa/>

The pointing was performed on June 6, 2005, under non-optimal weather conditions (passing thick clouds; the seeing was $\sim 2''$). The observation was made of two consecutive spectroscopic integrations of equal exposure time; the details of these spectroscopic observations are reported in Table 1. The BFOSC instrument is equipped with a 1300×1340 pixels EEV CCD. Grism #4 and a slit width of $2''$ were used, providing a nominal spectral coverage of the 3500–8500 Å range and a final dispersion of 4.0 Å/pix.

Spectra, after cosmic-ray rejection, were reduced in the usual fashion; they were then background subtracted and optimally extracted (Horne 1986) using IRAF⁵. Wavelength calibration was performed using He-Ar lamps; the spectra were then flux-calibrated by using the spectrophotometric standard BD+25°3941 (Stone 1977). The two spectra were eventually stacked together to increase the S/N ratio. Wavelength calibration was cross-checked using the night sky lines; the error is ~ 0.5 Å.

3 Results and discussion

The spectrum of 2MASX J14585116–1652223 acquired in Loiano (Fig. 2), albeit noisy, shows a number of emission features which we identified with redshifted optical lines typical of active galaxies. These include [O III] $\lambda\lambda 4958, 5007$, H_α and [N II] $\lambda\lambda 6549, 6583$. All identified emission lines are reported in Table 2 and yield a redshift of $z = 0.068 \pm 0.001$. Thus, 2MASX J14585116–1652223 is indeed an extragalactic object. Besides the extragalactic nature of this source, we also emphasize that this result, together with the X-ray information gathered with *BeppoSAX* (Landi et al. 2005), indicates that 2MASX J14585116–1652223 is the host galaxy of one of the few hard X-ray AGNs detected so far in the 20–100 keV band. In particular, this is one of the very few AGNs detected in the hard X-ray band and lying at redshifts larger than $z = 0.05$ (e.g., Perola et al. 2002; Risaliti 2002).

The fluxes of the emission features observed in the spectrum of Fig. 2 are reported as well in Table 2 and are corrected for the Galactic absorption. This correction was applied assuming a color excess $E(B - V) = 0.10$ towards the direction of 2MASX J14585116–1652223 (Schlegel et al. 1998) and the Galactic extinction law of Cardelli et al. (1989). The H_β emission is not detected: the 3σ upper limit of its flux is reported in Table 2.

⁵ IRAF is the Image Analysis and Reduction Facility made available to the astronomical community by the National Optical Astronomy Observatories, which are operated by AURA, Inc., under contract with the U.S. National Science Foundation. It is available at <http://iraf.noao.edu/>

The relative narrowness ($\approx 800 \text{ km s}^{-1}$) of the H_α line width is found to be comparable with those of forbidden nebular lines of $[\text{O III}]$ and $[\text{N II}]$; moreover, no broad component for the Balmer lines is detected. The observed emission line flux ratios $[\text{N II}]/\text{H}_\alpha \sim 1$ and $[\text{O III}]/\text{H}_\beta > 10$ clearly identify this source as a Type 2 Seyfert galaxy when compared to the diagnostic diagrams of Veilleux & Osterbrock (1987). This classification fits with the suggestions of Landi et al. (2005) who, through the analysis of X-ray data from this source collected with *BeppoSAX*, conclude that this is an AGN with substantial intrinsic absorption in the X-ray band.

The lower limit on the $\text{H}_\alpha/\text{H}_\beta$ line ratio can be used to give an estimate of the lower limit to the extinction towards the narrow-line region (NLR) of the AGN hosted by the galaxy 2MASX J14585116–1652223. The $\text{H}_\alpha/\text{H}_\beta$ flux ratio, once corrected for Galactic absorption, is > 6.2 . Next, considering an intrinsic Balmer decrement of $\text{H}_\alpha/\text{H}_\beta = 3.1$ for the gas conditions in a NLR (Osterbrock 1989) and the extinction law by Cardelli et al. (1989), the lower limit on the Balmer decrement $\text{H}_\alpha/\text{H}_\beta > 6.2$ implies an extinction $A_V > 2.2$ mag (in the galaxy rest frame). This latter lower limit can be compared with the neutral hydrogen column density N_{H} inferred from the X-ray spectrum of the source obtained with *BeppoSAX*. Using the empirical formula of Predehl & Schmitt (1995), $N_{\text{H}} = A_V(\text{mag}) \cdot 1.79 \times 10^{21} \text{ cm}^{-2}$, the lower limit on A_V implies a hydrogen column density towards the NLR of this AGN of $N_{\text{H}} > 3.9 \times 10^{21} \text{ cm}^{-2}$. This limit is fully consistent with the value for N_{H} inferred from X-ray data ($N_{\text{H}} = 4 \times 10^{22} \text{ cm}^{-2}$).

The comparison between the $[\text{O III}] \lambda 5007$ emission flux (see Table 2) and the 2–10 keV X-ray flux implies an X-ray/ $[\text{O III}]_{5007}$ ratio of ~ 80 , indicating that the source is in the Compton-thin regime (see Bassani et al. 1999). We however caution the reader that this is an upper limit to the ratio, since the flux of the $[\text{O III}] \lambda 5007$ line is not corrected for dust extinction intrinsic to the galaxy 2MASX J14585116–1652223.

Using a cosmology with $H_0 = 71 \text{ km s}^{-1} \text{ Mpc}^{-1}$, $\Omega_\Lambda = 0.7$ and $\Omega_m = 0.3$, we find that the luminosity distance to the galaxy 2MASX J14585116–1652223 is $d_L = 307 \text{ Mpc}$, and that its X-ray luminosities are $1.0 \times 10^{43} \text{ erg s}^{-1}$ and $1.2 \times 10^{44} \text{ erg s}^{-1}$ in the 2–10 keV and 20–100 keV bands, respectively. In parallel, again by correcting for the Galactic reddening, the absolute B -band magnitude of the galaxy is $M_B \sim -21.4$; we again remark that the latter is actually a lower limit to the optical luminosity, as no correction for absorption intrinsic to the object was made. These values indicate that this source is a fairly luminous Type 2 AGN (see, e.g., Malizia et al. 1999).

4 Conclusions

Through medium-resolution optical spectroscopy collected at the Cassini telescope of the Astronomical Observatory of Bologna we determined the nature and the distance of the serendipitous source 2MASX J14585116–1652223, formerly detected in X-rays with *BeppoSAX*. We identified this object as a Type 2 Seyfert galaxy at redshift $z = 0.068 \pm 0.001$. This redshift implies a luminosity distance of $d_L = 307$ Mpc to the source, which in turn allowed us to state that this AGN is in the bright side of the distribution both in X-rays and in optical. This result also indicates that this object is the host galaxy of one of the very few AGNs detected up to now in the hard X-ray band between 20 and 100 keV, especially at redshifts larger than $z = 0.05$. The acquired spectrum also gave us the possibility of determining other parameters for this galaxy such as its Compton-thinness and a lower limit on the reddening towards the NLR of the AGN hosted in the galaxy 2MASX J14585116–1652223.

In the close future, thanks to their capabilities, *INTEGRAL* and *ASTRO-E2* (“*Suzaku*”) will provide larger samples of distant sources detected at energies above 20 keV, to which the properties of 2MASX J14585116–1652223 will be compared.

Acknowledgements. We thank A. De Blasi for the night assistance in Loiano. This research has made use of the NASA Astrophysics Data System Abstract Service, of the NASA/IPAC Extragalactic Database (NED), and of the NASA/IPAC Infrared Science Archive, which are operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration. This research has also made use of the SIMBAD database operated at CDS, Strasbourg, France. NM thanks the European Southern Observatory in Vitacura, Santiago (Chile) for the pleasant hospitality during the preparation of this paper. We moreover thank the anonymous referee for several useful remarks and comments which helped us to improve this paper.

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Table 1

Log of the spectroscopic observations of 2MASX J14585116–1652223 presented in this paper.

Date	Mid-exp. time (UT)	Grism	Slit width (arcsec)	Exp. time (s)
06 Jun 2005	20:59:04	#4	2.0	2×1800

Table 2

Observer’s frame wavelengths (in Ångstroms) and fluxes (in units of 10^{-15} erg s $^{-1}$ cm $^{-2}$) of the emission lines detected in the spectrum of Fig. 2. Flux values are corrected for Galactic absorption assuming $E(B - V) = 0.10$ along the 2MASX J14585116–1652223 line of sight (Schlegel et al. 1998). The error on the line positions is conservatively assumed to be ± 4 Å, i.e., comparable with the spectral dispersion (see text). The upper limit on the flux of the H $_{\beta}$ emission line was computed at the expected wavelength for this line (reported in square brackets) assuming a redshift $z = 0.068$ for the source.

λ_{obs} (Å)	Line	Flux
[5192]	H $_{\beta}$	<0.9
5296	[O III] λ 4958	2.4 \pm 0.5
5349	[O III] λ 5007	9.0 \pm 0.9
6993	[N II] λ 6549	2.3 \pm 0.4
7012	H $_{\alpha}$	5.6 \pm 0.6
7035	[N II] λ 6583	6.3 \pm 0.6

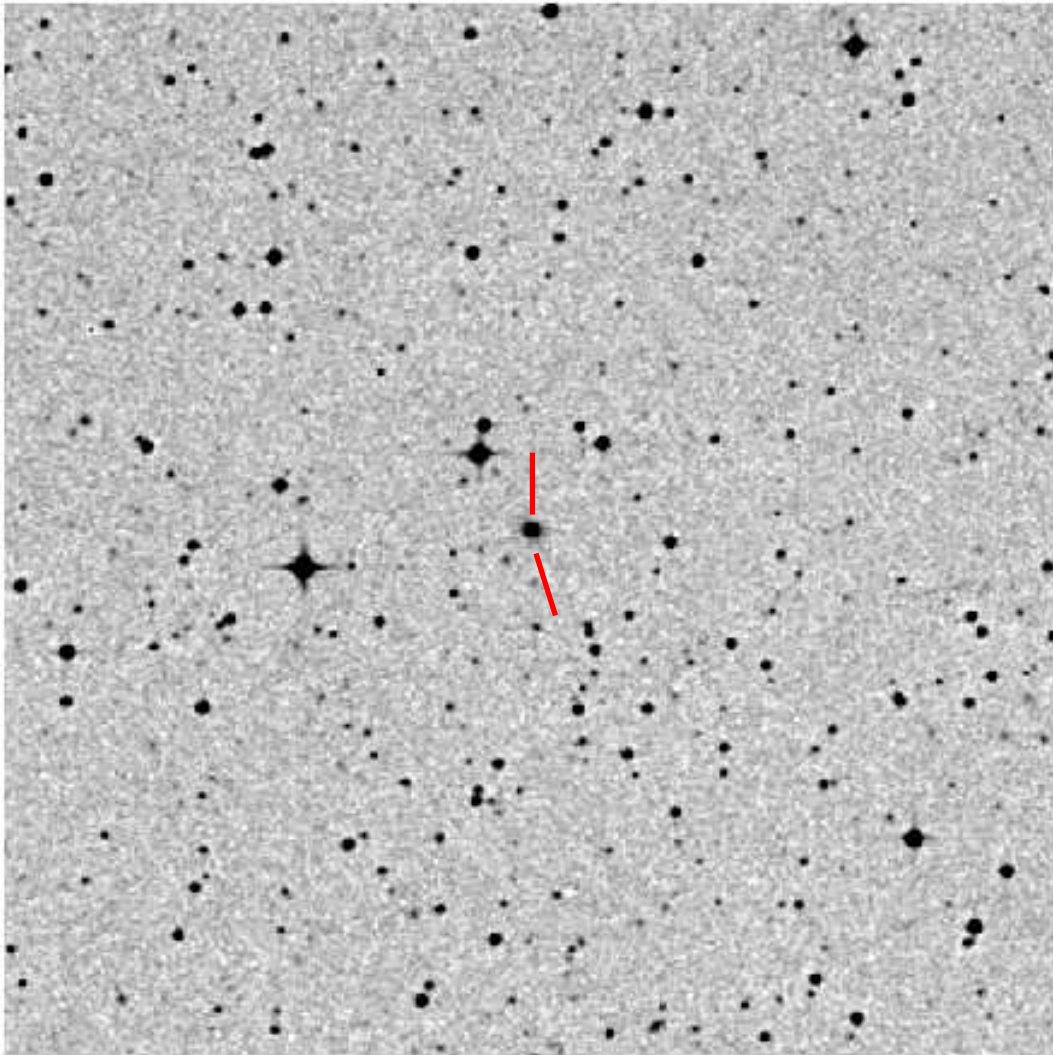


Fig. 1. DSS-II-Red image of the 2MASX J14585116–1652223 field. North is up and East to the left. The field size is $10' \times 10'$. The tick marks indicate the position of the source.

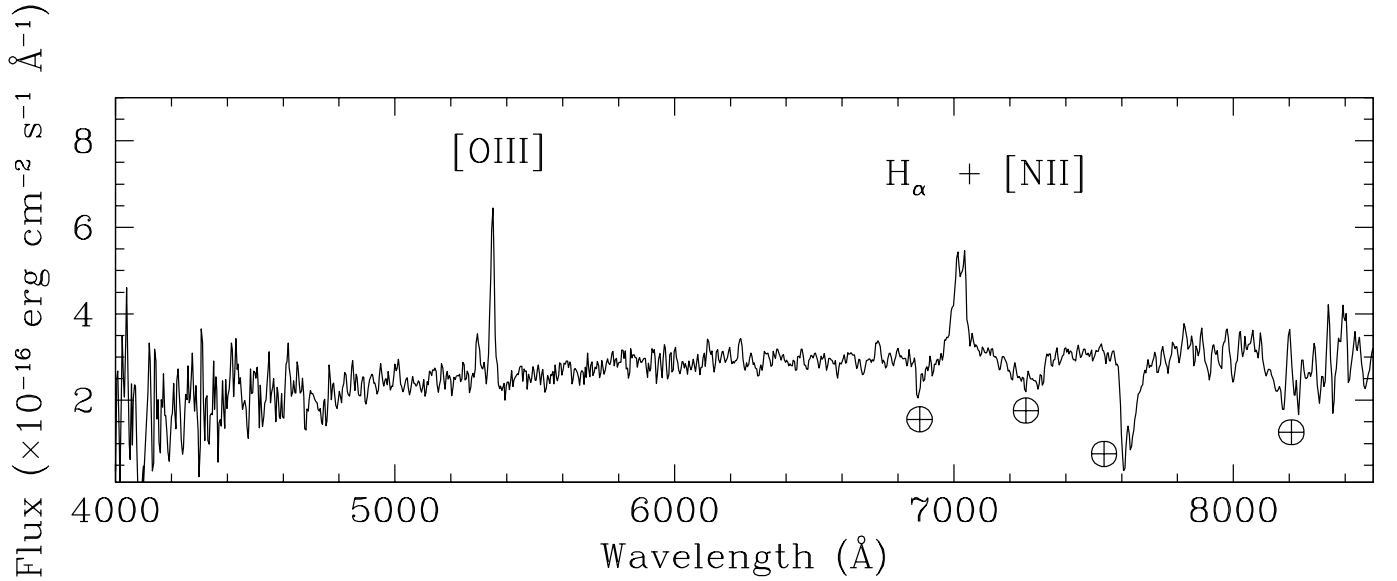


Fig. 2. Average optical spectrum (not corrected for the Galactic reddening) of 2MASX J14585116–1652223 acquired with the Cassini telescope in Loiano. The main spectral features are labeled (see also Table 2). These allowed us to determine the redshift of the source as $z = 0.068$. The symbol \oplus indicates atmospheric telluric features.